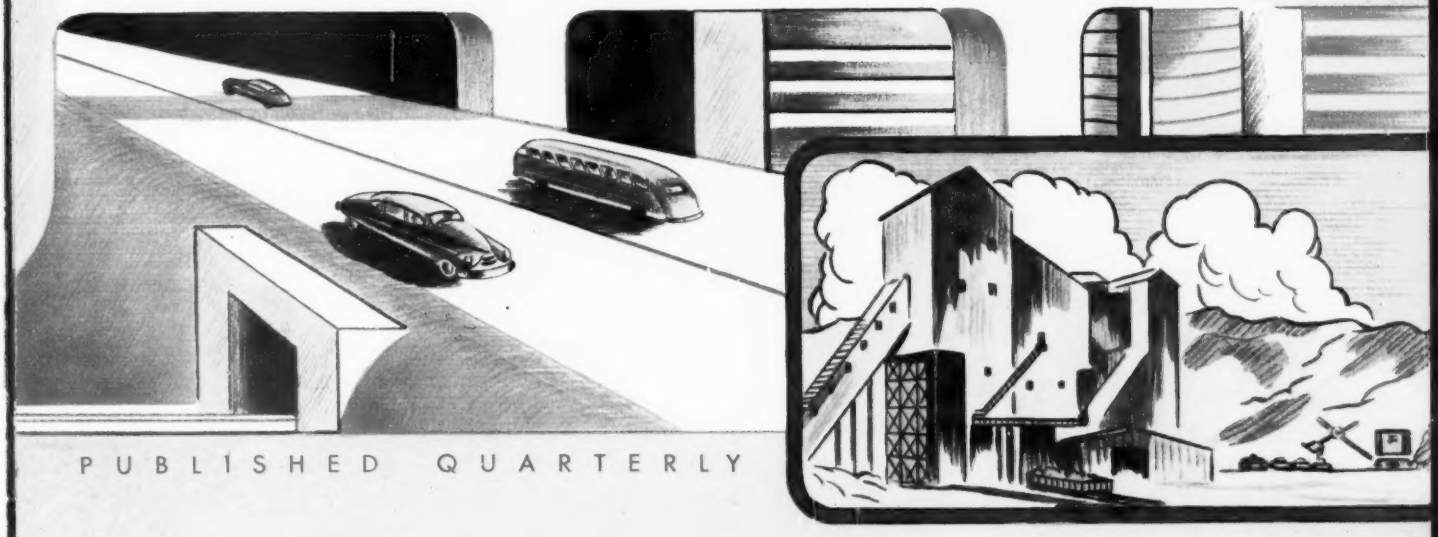
The CRUSHED STONE JOURNAL



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- **National Crushed Stone Association Safety Competition of 1953**
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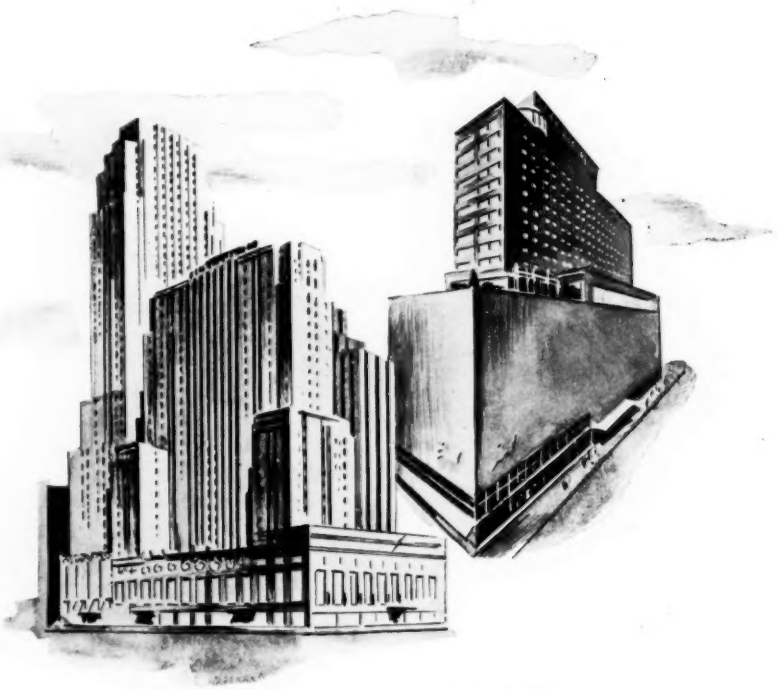

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THE
CRUSHED STONE JOURNAL

WASHINGTON, D. C.

Vol. XXIX No. 3 PUBLISHED QUARTERLY SEPTEMBER 1954

NCSA Laboratory Acquires Automatic Freezing-and-Thawing Apparatus

By James M. Rice

Research and Testing Engineer
National Crushed Stone Association
Washington, D. C.

Introduction

THE laboratory of the National Crushed Stone Association is pleased to announce the acquisition of an automatic freezing-and-thawing apparatus. The machine will be used for determining the resistance of concrete specimens to rapidly repeated cycles of freezing and thawing. Durability investigations which formerly required from six to eighteen months may now be completed in three to six weeks. Thus the laboratory will be able to expedite concrete research problems and provide more rapid service in the evaluation of concrete aggregates for members of the Association.

For many years the laboratory has been conducting durability tests on concrete specimens. The old freezing equipment consists of a brine tank in which cans holding the concrete beams are immersed. Beams are usually frozen overnight and removed from the freezer for thawing during the daytime. In addition to considerable heavy lifting, this procedure is slow in that it is possible to obtain only 5 cycles a week. Concrete mixes with entrained air are quite durable even with the poorest of aggregates. When frozen in water such mixes may withstand 50 to 100 cycles, while concrete made with more durable stone may require 200 or 300 cycles for completion of durability exposure, depending upon whether frozen in water or in air. Because of the time element, this method has not been suitable as an acceptance test for aggregates. The sulfate soundness test has been and is being used as an acceptance test, even though most materials engineers realize that it is not dependable in that it may lead to the acceptance of inferior aggregates and the rejection of sound materials. Now that rapid freezing-and-thawing machines are being acquired by more testing laboratories, it is anticipated that the sulfate soundness test will decline in importance.

Automatic Operation

The new freezing-and-thawing apparatus was manufactured to specifications by the Carrier Division of United Clay Products Company. This company has previously made units which are now in use at the National Sand and Gravel Association, Purdue University, and Kentucky Department of Highways. Figure 1 shows an over-all view of the unit.

The freezing-and-thawing chamber is a 2 1/2 by 2 1/2 by 3 1/2 ft compartment on the right hand side of the large box. Fin-type cooling coils and 2 air circulating fans are located in the adjacent space to the left. The compressor, 5 hp motor, and pumps for circulating and draining the thaw water are located behind the control panel. The thaw water is stored and heated in the long narrow tank at the rear of the unit.

The beams are stored in the basket as shown in Figure 2. By using 2 baskets stacked vertically, the unit has a capacity of seventy-two 3 by 3 by 11 in. beams. Access to the beams is facilitated by means of the electric hoist. The refrigerant, Freon-12, is water-cooled by means of a cooling tower which is

FIGURE 1
NCSA Automatic Freezing-and-Thawing Apparatus

located behind the wall in the next room. The temperature recorder mounted above the control panel (See Figure 3) indicates the temperature inside the freezing-and-thawing chamber.

The installation as shown is complete except for a platform which will extend across the front of the unit, and a rack to be erected just to the right of the unit for holding a basket when necessary. An additional item of equipment that has been developed is the device for measuring the temperature at the centers of control specimens placed at various locations within the freezer. This device will be described in more detail later.

In operation, the cold air is circulated by 2 fans in a clockwise direction up through the cooling coils and down through the compartment containing baskets of beams. When the beams have attained the desired low temperature, thawing is accomplished by circulating water at a controlled temperature through the storage compartment. The water enters at the bottom of the chamber and overflows out the back. After completion of the thawing phase, the water is pumped back into the storage tank. The timing of these operations is automatically controlled by adjustable timers.

The apparatus was designed to meet the requirements of ASTM Designation C 291-52T, Tentative Method of Test for Resistance of Concrete Specimens to Rapid Freezing in Air and Thawing in Water. This test requires that the temperature at the centers of all specimens be reduced from 40 to 0 F in less than 3 hours. Likewise, in the thawing phase, the temperature change from 0 to 40 F shall be accomplished in less than 1 hour.

The diagram in Figure 4 shows the temperature-time curves that were obtained in the acceptance tests for the apparatus. The capacity load of beams included 4 control specimens containing temperature sensitive elements (thermistors). From this diagram it is evident that the freezing phase required about 2 hours, 10 min., while the thawing consumed 25 min. Thus a complete cycle is made in 2 1/2 hours, which will enable us to attain almost 10 cycles per day, or 70 cycles per week.

At intervals of not more than 30 cycles, or twice a week, beams will be removed to determine their state of disintegration. This is accomplished by measuring the vibration characteristics of the specimens. A decrease in the resonant frequency of vibration indicates a reduction in strength or, more

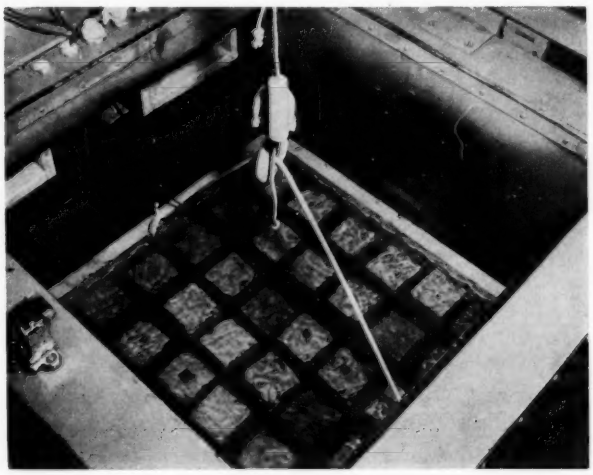

FIGURE 2
Thaw Water Circulating Over Beams in Freezing Chamber

correctly, a reduction in modulus of elasticity. A beam is considered to have failed when its modulus of elasticity (which is proportional to the square of the resonant frequency) reaches 60 per cent of its initial value. A beam is judged durable if it does not fail in 300 cycles.

Temperature Calibration Device

In order to adjust the apparatus to obtain the desired temperature cycles, it was necessary to find some means for the accurate measurement of temperatures at the centers of the concrete specimens. Thermocouples are usually employed for this purpose, but the purchase of an expensive accessory potentiometer for an operation that would be performed only occasionally did not seem justified. At the suggestion of D. W. Lewis of Purdue University, it was decided to employ thermistors. These are thermally sensitive resistors made of a solid semiconducting material whose resistance decreases about 4 per cent per degree Centigrade. For example, their resistance may be 14,000 ohms at 0 F and 4,000

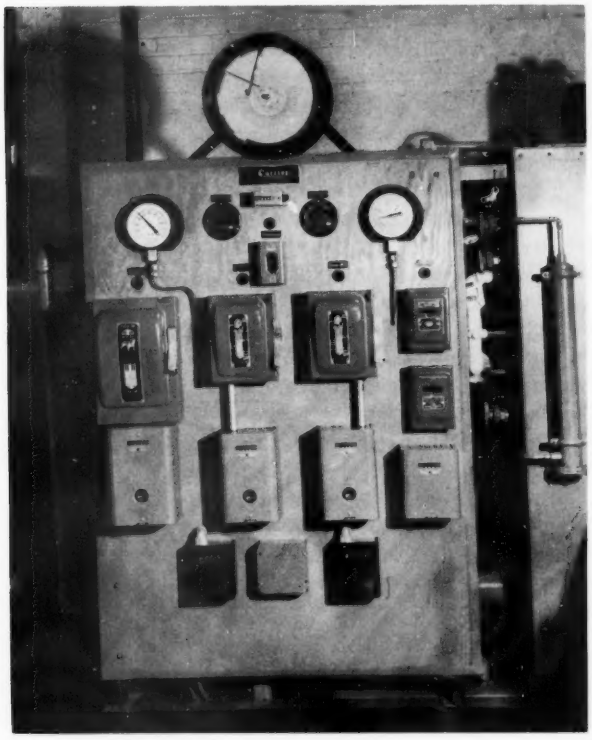

FIGURE 3
Control Panel and Temperature Recorder

ohms at 40 F. The sensitive material is a small particle of metallic oxide enclosed in a 1/2 in. long by 1/10 in. diameter glass bead.

It is possible to read the resistance of the thermistors directly with an accurate ohmmeter. However, it was decided that greater accuracy could be obtained by using a microammeter in an unbalanced Wheatstone bridge circuit. The bridge circuit that was developed at the laboratory is shown in Figure 5. The physical units are shown in Figure 6.

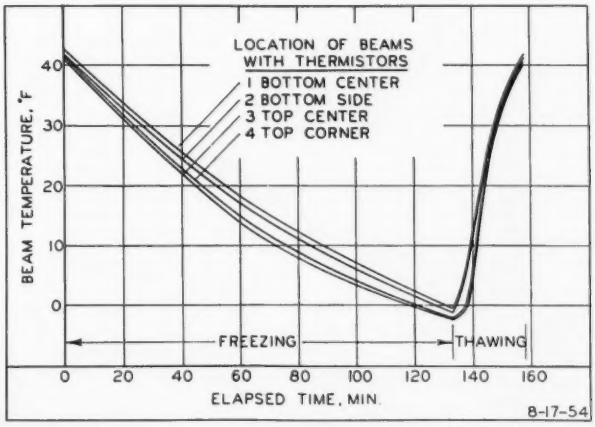

FIGURE 4
Time-Temperature Curves for Centers of Concrete Beams

This circuit is not purposely balanced at any stage of the operation. In the range of 0 to 40 F. current will flow through the microammeter (from J4 to J3) due to the lower resistance of the thermistors as compared to the preset variable resistance

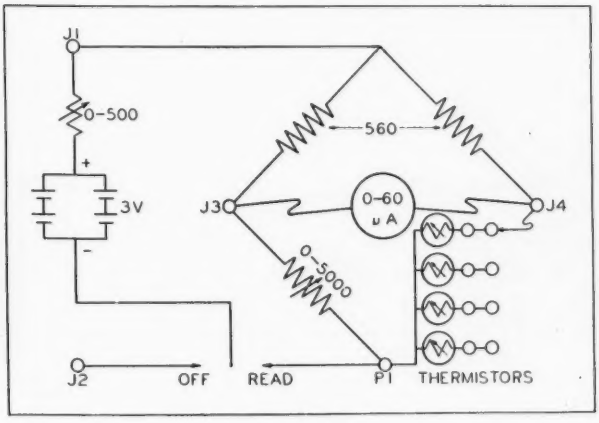

FIGURE 5
Circuit Diagram for Thermistor-Bridge Temperature Measuring Device

in the opposite side of the bridge. The current will be highest at the low operating temperature due to the negative temperature coefficient of resistance of the thermistor. As the temperature is in-

creased, the thermistor resistance decreases and at some temperature above 40 F it will balance that of the variable resistance and no current will flow through the meter.

To prepare the thermistors for use, it was first necessary to attach and insulate lead wires. A cali-

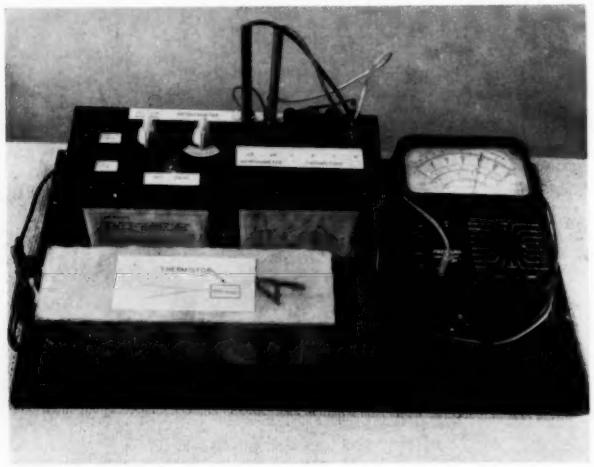

FIGURE 6
Bridge, Meter, Concrete Beam, and Thermistor

bration curve for each thermistor was then prepared by measuring the current flow for various temperatures with the elements immersed in a cold water-alcohol solution. The accuracy of the calibration was limited to that of the mercury thermometer used to measure the solution temperature, or about 0.1 F. The elements were then molded into the centers of the concrete beams to be used for control specimens.

Future Uses

In addition to testing the durability of specific aggregates, it is contemplated that the new freezing-and-thawing apparatus will be used to determine how the durability of concrete is affected by such factors as degree of saturation of concrete and aggregate, pore characteristics of aggregate, mix proportions, and air entrainment.

One of the first projects to be undertaken is the participation in a cooperative test program for the evaluation of standard procedures for determining the resistance of concrete to freezing and thawing. This program is sponsored by the Highway Research Board of the National Research Council. Dr. Bruce K. Foster of the National Bureau of Standards is chairman of the operating committee. Thirteen laboratories throughout the United States and Canada are engaging in the program. The development of standardized methods for the preparation and testing of concrete specimens for durability should benefit both the consumers and the producers of concrete aggregates, and help to insure more durable pavements and structures.

Several Committees to Study President's Road Proposal

THE functions of the various committees designed to study President Eisenhower's ten-year highway construction proposal are coming into focus.

The personnel of the Interagency Committee has been completed, and includes representatives of the Defense and Treasury Departments, the Bureau of the Budget, the Council of Economic Advisors, and the Bureau of Public Roads.

Francis V. DuPont, Commissioner of the Bureau of Public Roads, has been named Chairman of the group. Other members are: Defense, E. B. Smith, Director of Transportation and Communications, and (alternate) Gen. Paul F. Yount, Chief of Army Transportation; Treasury, Marion B. Folsom, Under Secretary of the Treasury; Bureau of the Budget, Harold L. Pearson, Assistant Director; Council of Economic Advisors, Maj. Gen. J. S. Bragdon (ret.), Coordinator, Public Works Planning.

The Clay Committee (headed by Gen. Lucius D. Clay), which was appointed by President Eisenhower to study his highway proposal, will begin holding hearings in Washington, D. C., the first week in October. It will sift out the plans submitted, and then forward any likely ones to the Interagency Committee.

The Interagency Committee will make recommendations on each plan it studies, the NHUC has learned, and send these recommendations on to White House Assistant Sherman Adams or to the President, himself.

The special Governors' Conference Committee will fit into this over-all pattern, too.

National Crushed Stone Association Safety Competition of 1953

By ELIZABETH K. ELSNER
and C. A. BLUM

Under Supervision of Seth T. Reese
Chief, Accident Analysis Branch
Health and Safety Division
U. S. Bureau of Mines
Washington, D. C.

THE over-all injury experience at crushed stone plants that participated in the National Crushed Stone Association Safety Competition of 1953 was one of the best in the 28-year history of the contest according to the Bureau of Mines, United States Department of the Interior. The injury-severity rate, 2.336 days of lost-time for each thousand man-hours of work or exposure to hazards, was the second lowest rate on record, a marked improvement over that of 1952, and sharply better than the rate recorded in 1926, the year the contest began. The frequency rate, 17.273 injuries per million man-hours of worktime in the 1953 competition was the lowest rate since 1939, and was the third best rate recorded during the 28 years of the contest. The safety performance at crushed stone operations in 1953 was another step in the continuing progress made by the industry in keeping accidents and the resulting injuries to a minimum. The current records attest to the cooperation of employee and management in well-founded accident prevention programs and the usefulness of safety contests as a means to obtain an end. Work can be done safely if the will and desire are sincere.

The Winning Operation

Enrolled for the first time in the competition, the Greystone quarry of the Greystone Granite Quarries, Incorporated at Henderson, Vance County, North Carolina won top honors for having an operating time of 190,859 man-hours without a lost-time or disabling injury. For this outstanding record in safety it is awarded a bronze plaque provided by the Explosives Engineer Magazine. In addition to the trophy-award, each employee who worked at the plant is awarded a certificate by the Association in recognition of his part in making that record at the plant possible.

The Kimballton underground limestone mine of the Standard Lime and Stone Company at Kimballton, Giles County, Virginia, ranked in second place in the 1953 contest with an outstanding achievement of being worked 156,818 man-hours without any disabling injuries. Third place in the competition was the Bakerton underground limestone mine of the Standard Lime and Stone Company at Bakerton, Jefferson County, West Virginia which had an injury-free record during a year's work period of 152,088 man-hours. The fourth-ranking operation was the Red Hill quarry of the Superior Stone Company at North Garden, Albemarle County, Virginia. This plant had no lost-time injuries during 135,772 man-hours of worktime.

Injury-Free Operations

Including the trophy winner, there were 2 underground mines and 16 quarries that had no disabling injuries during the contest year. These 18 mines and quarries were worked a total of 1,667,894 man-hours or 21 per cent of the total time worked by all 53 operations participating in the 1953 contest.

These injury-free plants, excluding the trophy winner, were as follows:

Kimballton mine, Standard Lime and Stone Company, Kimballton, Giles County, Virginia; 156,818 man-hours.

Bakerton mine, Standard Lime and Stone Company, Bakerton, Jefferson County, West Virginia; 152,088 man-hours.

Red Hill quarry, Superior Stone Company, North Garden, Albemarle County, Virginia; 135,772 man-hours.

White Haven quarry, General Crushed Stone Company, White Haven, Luzerne County, Pennsylvania; 128,629 man-hours.

Bakers quarry, Superior Stone Company, Monroe, Union County, North Carolina; 121,813 man-hours.

Bedford quarry, Blue Ridge Stone Corporation, Bedford, Bedford County, Virginia; 111,136 man-hours.

TABLE I

RELATIVE STANDING OF QUARRIES IN THE 1953 NATIONAL CRUSHED STONE ASSOCIATION SAFETY COMPETITION, BASED UPON THE INJURY-SEVERITY RATES OF THE QUARRIES[1]

Rank	Man-hours worked	Number of injuries[2]					Average days of disability per temp. injury	Number of days of disability[2]					Frequency rate[3]	Severity rate[3]
		F.	P.T.	P.P.	Temp.	Total		F.	P.T.	P.P.	Temp.	Total		
1	190,859	—	—	—	—	—	—	—	—	—	—	—	0.000	0.000
4	135,772	—	—	—	—	—	—	—	—	—	—	—	.000	.000
5	128,629	—	—	—	—	—	—	—	—	—	—	—	.000	.000
6	121,813	—	—	—	—	—	—	—	—	—	—	—	.000	.000
7	111,136	—	—	—	—	—	—	—	—	—	—	—	.000	.000
8	100,241	—	—	—	—	—	—	—	—	—	—	—	.000	.000
9	90,125	—	—	—	—	—	—	—	—	—	—	—	.000	.000
10	82,647	—	—	—	—	—	—	—	—	—	—	—	.000	.000
11	82,064	—	—	—	—	—	—	—	—	—	—	—	.000	.000
12	73,215	—	—	—	—	—	—	—	—	—	—	—	.000	.000
13	60,280	—	—	—	—	—	—	—	—	—	—	—	.000	.000
14	55,987	—	—	—	—	—	—	—	—	—	—	—	.000	.000
15	42,120	—	—	—	—	—	—	—	—	—	—	—	.000	.000
16	41,420	—	—	—	—	—	—	—	—	—	—	—	.000	.000
17	30,080	—	—	—	—	—	—	—	—	—	—	—	.000	.000
18	12,600	—	—	—	—	—	—	—	—	—	—	—	.000	.000
19	302,419	—	—	—	1	1	3	—	—	—	3	3	3.307	.010
20	51,248	—	—	—	1	1	1	—	—	—	1	1	19.513	.020
21	115,996	—	—	—	1	1	7	—	—	—	7	7	8.621	.060
22	405,600	—	—	—	2	2	14	—	—	—	27	27	4.931	.067
23	23,232	—	—	—	1	1	2	—	—	—	2	2	43.044	.086
24	43,680	—	—	—	1	1	5	—	—	—	5	5	22.894	.114
25	240,173	—	—	—	4	4	11	—	—	—	44	44	16.655	.183
26	133,828	—	—	—	1	1	25	—	—	—	25	25	7.472	.187
27	156,994	—	—	—	4	4	9	—	—	—	34	34	25.479	.217
29	134,900	—	—	—	4	4	11	—	—	—	45	45	29.652	.334
30	284,319	—	—	1	2	3	11	—	—	75	21	96	10.552	.338
31	328,640	—	—	—	2	2	56	—	—	—	112	112	6.086	.341
32	70,400	—	—	—	2	2	14	—	—	—	28	28	28.409	.398
33	97,080	—	—	1	—	1	—	—	—	42	—	42	10.301	.433
35	23,458	—	—	—	2	2	6	—	—	—	12	12	85.259	.512
37	243,111	—	—	—	16	16	10	—	—	—	155	155	65.814	.638
38	71,700	—	—	—	1	1	53	—	—	—	53	53	13.947	.739
40	53,122	—	—	—	3	3	14	—	—	—	43	43	56.474	.809
41	178,690	—	—	—	16	16	9	—	—	—	149	149	89.541	.834
42	126,489	—	—	—	3	3	36	—	—	—	108	108	23.717	.854
43	76,367	—	—	—	2	2	34	—	—	—	68	68	26.189	.890
44	156,250	—	—	—	5	5	39	—	—	—	197	197	32.000	1.261
45	224,505	—	—	—	4	4	81	—	—	—	324	324	17.817	1.443
46	70,588	—	—	—	2	2	75	—	—	—	149	149	28.333	2.111
47	170,282	—	—	—	1	1	365	—	—	—	365	365	5.873	2.144
48	728,872	—	—	2	11	13	19	—	—	1,875	208	2,083	17.836	2.858
49	125,089	—	—	1	—	1	—	—	—	600	—	600	7.994	4.797
50	190,361	—	—	1	3	4	35	—	—	1,800	106	1,906	21.013	10.013
51	274,635	—	—	1	18	19	31	—	—	4,500	556	5,056	69.183	18.410
52	62,598	—	—	1	1	2	35	—	—	1,500	35	1,535	31.950	24.522
53	31,719	—	—	1	—	1	—	—	—	4,500	—	4,500	31.527	141.871
Totals and rates:														
1953	6,555,333	—	—	9	114	123	25	—	—	14,892	2,882	17,774	18.763	2.711
1952	5,279,849	3	—	3	111	117	21	18,000	—	1,674	2,296	21,970	22.160	4.161

[1] As reports from mining companies are considered confidential by the Bureau of Mines, the identities of the operations to which this table relates are not revealed

[2] F., fatal; P. T., permanent total disability; P. P., permanent partial disability; Temp., temporary disability

[3] Frequency rate indicates the number of fatal, permanent, and other disabling injuries per million man-hours of exposure; severity rate indicates the number of days of disability lost from injuries per thousand man-hours of exposure

Auburn quarry, General Crushed Stone Company, Auburn, Cayuga County, New York; 100,241 man-hours.

Rock Hill quarry, General Crushed Stone Company, Quakertown, Bucks County, Pennsylvania; 90,125 man-hours.

Watertown quarry, General Crushed Stone Company, Watertown, Jefferson County, New York; 82,647 man-hours.

Cedar Hollow quarry, Warner Company, Devault, Chester County, Pennsylvania; 82,064 man-hours.

Jordanville quarry, General Crushed Stone Company, Jordanville, Herkimer County, New York; 73,215 man-hours.

Holston quarry, American Limestone Company, Mascot, Knox County, Tennessee; 60,280 man-hours.

Joliet quarry, Lincoln Crushed Stone Company, Joliet, Will County, Illinois; 55,987 man-hours.

Stoughton quarry, Stoughton Crushed Stone Company, Stoughton, Plymouth County, Massachusetts; 42,120 man-hours.

Prospect Stone Plant No. 6 quarry, Eastern Rock Products, Incorporated, Prospect, Oneida County, New York; 41,420 man-hours.

Waukesha quarry, Waukesha Lime and Stone Company, Incorporated, Waukesha, Waukesha County, Wisconsin; 30,080 man-hours.

Randville quarry, Superior Rock Products Company, Iron Mountain, Dickinson County, Michigan; 12,600 man-hours.

Statistics of the Competition

The rates of frequency and severity of injuries at the 53 enrolled operations in 1953 were considerably lower than their respective averages for the 28-year history of the contest. The frequency-rate of 17.273 injuries per million man-hours was the second lowest annual rate, 41 per cent better than the 28-year average, and a 19-per cent improvement compared with the rate of the previous year. The severity rate of 2.336 days lost per thousand man-hours was the second best annual rate, 56 per cent lower than the 28-year average, and a 34-per cent improvement over the 1952 rate.

Man-hours of worktime at the competing plants in 1953 totalled 7,815,856,—6,555,333 at quarries and 1,260,523 at underground mines. During this volume of worktime, there were 135 lost-time injuries. Of this total, 9 were permanent partial and 126 were temporary total disabilities. Neither a fatality nor a permanent total injury was reported by the participating plants. The fatality-free year was the second of the 28 years of competition during which no one was killed and in only two years of the contest history have there been permanent total injuries reported. The average disability of the temporary total injuries was 27 days.

Forty-seven open quarries and 6 underground mines were enrolled in the 1953 competition. The injury-frequency rate at the quarries was 18.763 per million man-hours and the severity rate was 2.711 days lost per thousand man-hours. The frequency rate, a 15 per cent improvement over the 1952 rate, was 36 per cent lower than the average rate for the 28 years of the contest and it was the fourth best rate in the history of the competition. The severity rate, the fifth lowest rate yet recorded, was 35 per cent lower than the 1952 rate and 47 per cent better than the 28-year average.

At the 6 underground mines enrolled in the 1953 competition, the injury-frequency rate of 9.520 per million man-hours was the third lowest rate recorded since the beginning of the contest in 1926; it was 43 per cent lower than the 1952 rate and 68 per cent better than the 28-year average. The severity rate of 0.386 day per thousand man-hours of work was bettered in only one year—1937—when

TABLE II

RELATIVE STANDING OF UNDERGROUND MINES IN THE 1953 NATIONAL CRUSHED STONE ASSOCIATION SAFETY COMPETITION, BASED UPON THE INJURY-SEVERITY RATES OF THE MINES[1]

Rank	Man-hours worked	Number of injuries [2]					Average days of disability per temp. injury	Number of days of disability [2]					Frequency rate [3]	Severity rate [3]
		F.	P.T.	P.P.	Temp.	Total		F.	P.T.	P.P.	Temp.	Total		
2	156,818	—	—	—	—	—	—	—	—	—	—	—	0.000	0.000
3	152,088	—	—	—	—	—	—	—	—	—	—	—	.000	.000
28	370,853	—	—	—	2	2	59	—	—	—	118	118	5.393	.318
34	202,797	—	—	—	1	1	88	—	—	—	88	88	4.931	.434
36	104,905	—	—	—	3	3	21	—	—	—	62	62	28.597	.591
39	273,062	—	—	—	6	6	37	—	—	—	219	219	21.973	.802
Totals and rates:														
1953	1,260,523	—	—	—	12	12	41	—	—	—	487	487	9.520	0.386
1952	1,137,449	—	—	—	19	19	31	—	—	—	583	583	16.704	0.513

[1] As reports from mining companies are considered confidential by the Bureau of Mines, the identities of the operations to which this table relates are not revealed

[2] F., fatal; P. T., permanent total disability; P. P., permanent partial disability; Temp., temporary disability

[3] Frequency rate indicates the number of fatal, permanent, and other disabling injuries per million man-hours of exposure; severity rate indicates the number of days of disability lost from injuries per thousand man-hours of exposure

TABLE III
YEARLY SUMMARY—QUARRIES IN THE NATIONAL CRUSHED STONE ASSOCIATION SAFETY COMPETITION, 1926–53 [1]

Year	Plants	Man-hours worked	Number of injuries [2]					Number of days of disability [2]					Frequency rate [3]	Severity rate [3]
			F.	P. T.	P. P.	Temp.	Total	F.	P. T.	P. P.	Temp.	Total		
1926	40	5,298,983	3	—	6	207	216	18,000	—	9,000	4,239	31,239	40.763	5.895
1927	48	7,876,791	9	—	2	458	469	54,000	—	2,100	7,186	63,286	59.542	8.034
1928	53	7,509,098	8	—	4	322	334	48,000	—	8,700	5,493	62,193	44.479	8.282
1929	53	7,970,325	4	—	5	286	295	24,000	—	5,760	5,533	35,293	37.012	4.428
1930	68	8,013,415	6	—	9	227	242	36,000	—	7,250	3,671	46,921	30.199	5.855
1931	58	5,085,857	4	—	13	198	215	24,000	—	18,660	3,540	46,200	42.274	9.084
1932	40	2,661,850	1	—	4	75	80	6,000	—	6,750	2,481	15,231	30.054	5.722
1933	40	2,704,871	1	—	1	67	69	6,000	—	48	2,893	8,941	25.510	3.306
1934	46	3,288,257	1	—	2	106	109	6,000	—	2,850	1,873	10,723	33.148	3.261
1935	46	4,166,306	2	1	8	77	88	12,000	6,000	9,900	3,015	30,915	21.122	7.420
1936	50	6,399,023	5	—	14	182	201	30,000	—	8,168	4,590	42,758	31.411	6.682
1937	47	6,199,001	7	—	9	136	152	42,000	—	5,875	4,461	52,336	24.520	8.443
1938	47	4,658,119	2	—	6	76	84	12,000	—	6,600	3,184	21,784	18.033	4.677
1939	44	4,219,086	2	—	2	51	55	12,000	—	4,800	1,678	18,478	13.036	4.380
1940	46	4,358,409	1	—	5	78	84	6,000	—	2,550	3,013	11,563	19.273	2.653
1941	47	5,777,587	3	—	5	98	106	18,000	—	9,300	2,266	29,566	18.347	5.117
1942	48	7,178,935	3	2	1	183	189	18,000	12,000	1,500	4,239	35,739	26.327	4.978
1943	34	4,750,314	4	—	5	134	143	24,000	—	7,146	3,862	35,008	30.103	7.370
1944	32	3,996,433	3	—	4	118	125	18,000	—	3,000	3,323	24,323	31.278	6.086
1945	46	6,087,037	—	—	1	135	136	—	—	750	3,505	4,255	22.343	0.699
1946	46	7,292,175	1	—	6	197	204	6,000	—	5,141	4,130	15,271	27.975	2.094
1947	42	6,971,790	5	—	5	197	207	30,000	—	6,900	4,990	41,890	29.691	6.008
1948	47	6,953,569	4	—	11	181	196	24,000	—	8,018	4,642	36,660	28.187	5.272
1949	57	7,166,644	3	—	11	153	167	18,000	—	9,465	3,345	30,810	23.302	4.299
1950	45	6,510,173	2	—	7	153	162	12,000	—	3,854	3,825	19,679	24.884	3.023
1951	36	5,441,304	1	—	4	100	105	6,000	—	6,325	2,381	14,706	19.297	2.703
1952	36	5,279,849	3	—	3	111	117	18,000	—	1,674	2,296	21,970	22.160	4.161
1953	47	6,555,333	—	—	9	114	123	—	—	14,892	2,882	17,774	18.763	2.711
Total	—	160,370,534	88	3	162	4,420	4,673	528,000	18,000	176,976	102,536	825,512	29.139	5.148

[1] As reports from mining companies are considered confidential by the Bureau of Mines, the identities of the operations to which this table relates are not revealed
[2] F., fatal; P. T., permanent total disability; P. P., permanent partial disability; Temp., temporary disability
[3] Frequency rate indicates the number of fatal, permanent, and other disabling injuries per million man-hours of exposure; severity rate indicates the number of days of disability lost from injuries per thousand man-hours of exposure

TABLE IV
YEARLY SUMMARY—UNDERGROUND MINES IN THE NATIONAL CRUSHED STONE ASSOCIATION SAFETY COMPETITION, 1926–53 [1]

Year	Plants	Man-hours worked	Number of injuries [2]					Number of days of disability [2]					Frequency rate [3]	Severity rate [3]
			F.	P. T.	P. P.	Temp.	Total	F.	P. T.	P. P.	Temp.	Total		
1926	3	517,926	—	—	—	34	34	—	—	—	533	533	65.646	1.029
1927	2	318,449	1	—	1	14	16	6,000	—	300	68	6,368	50.244	19.997
1928	5	542,193	1	—	1	68	70	6,000	—	300	888	7,188	129.105	13.257
1929	4	665,520	1	—	1	30	32	6,000	—	300	617	6,917	48.083	10.393
1930	6	595,367	1	—	1	15	17	6,000	—	225	468	6,693	28.554	11.242
1931	3	345,105	—	—	—	4	4	—	—	—	147	147	11.591	.426
1932	2	158,450	—	—	—	6	6	—	—	—	165	165	37.867	1.041
1933	3	229,381	—	—	—	11	11	—	—	—	349	349	47.955	1.521
1934	4	248,146	—	—	—	13	13	—	—	—	287	287	52.389	1.157
1935	2	175,994	—	—	—	3	3	—	—	—	249	249	17.046	1.415
1936	4	334,747	1	—	—	7	8	6,000	—	—	117	6,117	23.899	18.274
1937	3	364,680	—	—	—	3	3	—	—	—	91	91	8.226	.250
1938	3	334,442	—	—	—	2	2	—	—	—	133	133	5.980	.398
1939	4	393,039	—	—	1	7	8	—	—	600	457	1,057	20.354	2.689
1940	4	375,987	—	—	1	8	9	—	—	4,500	888	5,388	23.937	14.330
1941	4	591,568	—	—	1	15	16	—	—	750	169	919	27.047	1.553
1942	4	785,894	—	—	1	33	34	—	—	1,800	1,213	3,013	43.263	3.834
1943	5	1,019,771	—	—	3	45	48	—	—	4,950	1,123	6,073	47.069	5.955
1944	4	727,496	1	—	1	27	29	6,000	—	2,400	796	9,196	39.863	12.641
1945	7	1,238,845	—	—	2	22	24	—	—	3,000	755	3,755	19.373	3.031
1946	8	1,338,563	2	—	2	31	35	12,000	—	675	1,045	13,720	26.147	10.250
1947	8	1,291,162	5	—	1	29	35	30,000	—	75	1,588	31,663	27.107	24.523
1948	4	940,031	—	—	—	16	16	—	—	—	935	935	17.021	.995
1949	5	981,692	—	—	1	17	18	—	—	900	467	1,367	18.336	1.392
1950	6	1,102,273	1	—	1	25	27	6,000	—	3,000	810	9,810	24.495	8.900
1951	6	1,179,458	—	—	1	21	22	—	—	1,125	818	1,943	18.653	1.647
1952	6	1,137,449	—	—	—	19	19	—	—	—	583	583	16.704	.513
1953	6	1,260,523	—	—	—	12	12	—	—	—	487	487	9.520	.386
Total	—	19,194,151	14	—	20	537	571	84,000	—	24,900	16,246	125,146	29.749	6.520

[1] As reports from mining companies are considered confidential by the Bureau of Mines, the identities of the operations to which this table relates are not revealed
[2] F., fatal; P. T., permanent total disability; P. P., permanent partial disability; Temp., temporary disability
[3] Frequency rate indicates the number of fatal, permanent, and other disabling injuries per million man-hours of exposure; severity rate indicates the number of days of disability lost from injuries per thousand man-hours of exposure

TABLE V

YEARLY SUMMARY—QUARRIES AND UNDERGROUND MINES IN THE NATIONAL CRUSHED STONE ASSOCIATION SAFETY COMPETITION, 1926–53 [1]

Year	Plants	Man-hours worked	Number of injuries [2]					Number of days of disability [2]					Frequency rate [3]	Severity rate [3]
			F.	P. T.	P. P.	Temp.	Total	F.	P. T.	P. P.	Temp.	Total		
1926	43	5,816,909	3	—	6	241	250	18,000	—	9,000	4,772	31,772	42.978	5.462
1927	50	8,195,240	10	—	3	472	485	60,000	—	2,400	7,254	69,654	59.181	8.499
1928	58	8,051,291	9	—	5	390	404	54,000	—	9,000	6,381	69,381	50.178	8.617
1929	57	8,635,845	5	—	6	316	327	30,000	—	6,060	6,150	42,210	37.865	4.888
1930	74	8,608,782	7	—	10	242	259	42,000	—	7,475	4,139	53,614	30.086	6.228
1931	61	5,430,962	4	—	13	202	219	24,000	—	18,660	3,687	46,347	40.324	8.534
1932	42	2,820,300	1	—	4	81	86	6,000	—	6,750	2,646	15,396	30.493	5.459
1933	43	2,934,252	1	—	1	78	80	6,000	—	48	3,242	9,290	27.264	3.166
1934	50	3,536,403	1	—	2	119	122	6,000	—	2,850	2,160	11,010	34.498	3.113
1935	48	4,342,300	2	1	8	80	91	12,000	6,000	9,900	3,264	31,164	20.957	7.177
1936	54	6,733,770	6	—	14	189	209	36,000	—	8,168	4,707	48,875	31.038	7.258
1937	50	6,563,681	7	—	9	139	155	42,000	—	5,875	4,552	52,427	23.615	7.987
1938	50	4,992,561	2	—	6	78	86	12,000	—	6,600	3,317	21,917	17.226	4.390
1939	48	4,612,125	2	—	3	58	63	12,000	—	5,400	2,135	19,535	13.660	4.236
1940	50	4,734,396	1	—	6	86	93	6,000	—	7,050	3,901	16,951	19.643	3.580
1941	51	6,369,155	3	—	6	113	122	18,000	—	10,050	2,435	30,485	19.155	4.786
1942	52	7,964,829	3	2	2	216	223	18,000	12,000	3,300	5,452	38,752	27.998	4.865
1943	39	5,770,085	4	—	8	179	191	24,000	—	12,096	4,985	41,081	33.102	7.120
1944	36	4,723,929	4	—	5	145	154	24,000	—	5,400	4,119	33,519	32.600	7.096
1945	53	7,325,882	—	—	3	157	160	—	—	3,750	4,260	8,010	21.840	1.093
1946	54	8,630,738	3	—	8	228	239	18,000	—	5,816	5,175	28,991	27.692	3.359
1947	50	8,262,952	10	—	6	226	242	60,000	—	6,975	6,578	73,553	29.287	8.902
1948	51	7,893,600	4	—	11	197	212	24,000	—	8,018	5,577	37,595	26.857	4.763
1949	62	8,148,336	3	—	12	170	185	18,000	—	10,365	3,812	32,177	22.704	3.949
1950	51	7,612,446	3	—	8	178	189	18,000	—	6,854	4,635	29,489	24.828	3.874
1951	42	6,620,762	1	—	5	121	127	6,000	—	7,450	3,199	16,649	19.182	2.515
1952	42	6,417,298	3	—	3	130	136	18,000	—	1,674	2,879	22,553	21.193	3.514
1953	53	7,815,856	—	—	9	126	135	—	—	14,892	3,369	18,261	17.273	2.336
Total	—	179,564,685	102	3	182	4,957	5,244	612,000	18,000	201,876	118,782	950,658	29.204	5.294

[1] As reports from mining companies are considered confidential by the Bureau of Mines, the identities of the operations to which this table relates are not revealed
[2] F., fatal; P. T., permanent total disability; P. P., permanent partial disability; Temp., temporary disability
[3] Frequency rate indicates the number of fatal, permanent, and other disabling injuries per million man-hours of exposure; severity rate indicates the number of days of disability lost from injuries per thousand man-hours of exposure

TABLE VI

NUMBER OF INJURIES, BY CLASSIFICATIONS, AT QUARRIES AND UNDERGROUND MINES IN THE NATIONAL CRUSHED STONE ASSOCIATION SAFETY COMPETITION IN 1953

Classifications	Fatal	Permanent		Tempo-rary	Total
		Total	Partial		
Falls and slides of rock or materials	—	—	1	8	9
Handling materials or objects	—	—	—	33	33
Hand tools	—	—	1	3	4
Explosives	—	—	1	—	1
Haulage	—	—	—	16	16
Falls of persons	—	—	—	19	19
Bumping against objects	—	—	—	6	6
Falling objects	—	—	3	4	7
Flying objects	—	—	1	10	11
Electricity	—	—	—	2	2
Drilling	—	—	—	2	2
Machinery	—	—	2	5	7
Stepping on objects	—	—	—	9	9
Burns	—	—	—	2	2
Other causes	—	—	—	5	5
Total	—	—	9	124	133
Not stated	—	—	—	2	2
Grand total	—	—	9	126	135

TABLE VII

DAYS OF DISABILITY, BY CLASSIFICATIONS, OF INJURIES AT QUARRIES AND UNDERGROUND MINES IN THE NATIONAL CRUSHED STONE ASSOCIATION SAFETY COMPETITION IN 1953

Classifications	Fatal	Permanent		Tempo-rary	Total
		Total	Partial		
Falls and slides of rock or materials	—	—	600	363	963
Handling materials or objects	—	—	—	659	659
Hand tools	—	—	42	17	59
Explosives	—	—	1,800	—	1,800
Haulage	—	—	—	896	896
Falls of persons	—	—	—	454	454
Bumping against objects	—	—	—	103	103
Falling objects	—	—	1,650	33	1,683
Flying objects	—	—	1,800	175	1,975
Electricity	—	—	—	23	23
Drilling	—	—	—	62	62
Machinery	—	—	9,000	356	9,356
Stepping on objects	—	—	—	51	51
Burns	—	—	—	15	15
Other causes	—	—	—	67	67
Total	—	—	14,892	3,274	18,166
Not stated	—	—	—	95	95
Grand total	—	—	14,892	3,369	18,261

TABLE VIII

NUMBER AND PERCENTAGE DISTRIBUTION OF INJURIES AT PLANTS ENROLLED IN THE NATIONAL CRUSHED STONE ASSOCIATION SAFETY COMPETITION, 1950–53, BY CLASSIFICATIONS

Classifications	1951		1952		1953		Total	
	Number	Per cent of total	Number	Per cent of total	Number	Per cent of total	Number	Per cent of total
Falls and slides of rock	14	11.9	16	13.1	9	6.8	39	10.5
Handling materials	25	21.2	17	13.9	33	24.8	75	20.1
Hand tools	7	5.9	5	4.1	4	3.0	16	4.3
Explosives	1	.9	—	—	1	.7	2	.5
Haulage	5	4.2	11	9.0	16	12.0	32	8.6
Falls of persons	20	17.0	19	15.6	19	14.3	58	15.5
Bumping against objects	3	2.5	4	3.3	6	4.5	13	3.5
Falling objects	11	9.3	14	11.5	7	5.3	32	8.6
Flying objects	7	5.9	10	8.2	11	8.3	28	7.5
Electricity	—	—	4	3.3	2	1.5	6	1.6
Drilling	2	1.7	1	.8	2	1.5	5	1.3
Machinery	14	11.9	10	8.2	7	5.3	31	8.3
Stepping on objects	3	2.5	6	4.9	9	6.8	18	4.8
Burns	—	—	2	1.6	2	1.5	4	1.1
Other causes	6	5.1	3	2.5	5	3.7	14	3.8
Total	118	100.0	122	100.0	133	100.0	373	100.0
Causes not stated	9	—	14	—	2	—	25	—
Grand total	127	—	136	—	135	—	398	—

the rate was 0.250 day. The 1953 rate was almost 25 per cent lower than the 1952 rate and 94 per cent lower than the average for the history of the contest.

Causes and Severity of Injuries

Accidents involving the handling of materials were responsible for almost 25 per cent of all injuries for which stated causes were reported. Falls of persons accounted for 14 per cent, haulage accidents, 12 per cent, flying objects, 8 per cent, and falls and slides of rock, and accidents from stepping on objects, each caused 7 per cent. These six agencies were responsible for 73 per cent of the total number of injuries. The most severe injuries were caused by machinery accidents, flying objects, explosives accidents, and falling objects. These four agencies were responsible for 82 per cent of the total time lost from all disabling injuries.

TABLE IX

NUMBER OF AND PERCENTAGE DISTRIBUTION OF DAYS OF DISABILITY FROM INJURIES AT PLANTS ENROLLED IN THE NATIONAL CRUSHED STONE ASSOCIATION SAFETY COMPETITION, 1950–53, BY CLASSIFICATIONS

Classifications	1951		1952		1953		Total	
	Days of disability	Per cent of total	Days of disability	Per cent of total	Days of disability	Per cent of total	Days of disability	Per cent of total
Falls and slides of rock	3,306	20.5	6,688	30.1	963	5.3	10,957	19.4
Handling materials	503	3.1	259	1.2	659	3.6	1,421	2.5
Hand tools	60	.4	29	.1	59	.3	148	.3
Explosives	19	.1	—	—	1,800	9.9	1,819	3.2
Haulage	1,215	7.5	6,152	27.7	896	4.9	8,263	14.6
Falls of persons	1,049	6.5	6,384	28.7	454	2.5	7,887	14.0
Bumping against objects	86	.5	122	.5	103	.6	311	.6
Falling objects	212	1.3	281	1.3	1,683	9.3	2,176	3.8
Flying objects	81	.5	59	.3	1,975	10.9	2,115	3.7
Electricity	—	—	17	.1	23	.1	40	.1
Drilling	52	.3	16	.1	62	.3	130	.2
Machinery	3,449	21.4	1,903	8.6	9,356	51.5	14,708	26.0
Stepping on objects	64	.4	204	.9	51	.3	319	.6
Burns	—	—	65	.3	15	.1	80	.1
Other causes	6,062	37.5	22	.1	67	.4	6,151	10.9
Total	16,158	100.0	22,201	100.0	18,166	100.0	56,525	100.0
Causes not stated	491	—	352	—	95	—	938	—
Grand total	16,649	—	22,553	—	18,261	—	57,463	—

Summary of Tables

Tables I and II show the relative standing of open quarries and underground mines in descending order by injury-severity rates. When two or more plants had injury-free records, the number of man-hours is the guiding factor in establishing the order of rank. Tables III, IV, and V show yearly data on the participating plants from the beginning of the contest in 1926 through 1953. The number of injuries, days of disability, and percentage distribution by accident agencies are shown in Tables VI, VII, VIII, and IX. Table X contains data for identical and nonidentical plants that were enrolled in the contests of 1952 and 1953, and Table XI indicates the average time lost in days for temporary total disabilities.

TABLE X

EMPLOYMENT AND INJURY DATA FOR CRUSHED STONE PLANTS ENROLLED IN THE NATIONAL CRUSHED STONE ASSOCIATION SAFETY COMPETITION, 1952 AND 1953, COVERING IDENTICAL PLANTS FOR BOTH YEARS AND PLANTS ENROLLED ONLY IN 1952 OR IN 1953 [1]

	No.	Man-hours worked	Number of injuries [2]					Days of disability [2]					Frequency rate [3]	Severity rate [3]
			F.	P. T.	P. P.	Temp.	Total	F.	P. T.	P. P.	Temp.	Total		
Plants enrolled in 1952 only	9	760,841	—	—	1	14	15	—	—	624	405	1,029	19.715	1.352
Identical plants enrolled both years, 1952	33	5,656,457	3	—	2	116	121	18,000	—	1,050	2,474	21,524	21.391	3.805
Identical plants enrolled both years, 1953	33	5,523,483	—	—	3	93	96	—	—	6,375	2,511	8,886	17.380	1.609
Plants enrolled in 1953 only	20	2,292,373	—	—	6	33	39	—	—	8,517	858	9,375	17.013	4.090

[1] As reports from mining companies are considered confidential by the Bureau of Mines, the identities of the operations to which this table relates are not revealed
[2] F., fatal; P. T., permanent total disability; P. P., permanent partial disability; Temp., temporary disability
[3] Frequency rate indicates the number of fatal, permanent, and other disabling injuries per million man-hours of exposure; severity rate indicates the number of days of disability lost from injuries per thousand man-hours of exposure

TABLE XI

AVERAGE DAYS OF DISABILITY PER TEMPORARY INJURY AT PLANTS ENROLLED IN THE NATIONAL CRUSHED STONE ASSOCIATION SAFETY COMPETITION

Year	Underground mines			Open quarries			Total		
	Number of temporary injuries	Number of days of disability	Average days of disability	Number of temporary injuries	Number of days of disability	Average days of disability	Number of temporary injuries	Number of days of disability	Average days of disabiliy
1926	34	533	16	207	4,239	20	241	4,772	20
1927	14	68	5	458	7,186	16	472	7,254	15
1928	68	888	13	322	5,493	17	390	6,381	16
1929	30	617	21	286	5,533	19	316	6,150	19
1930	15	468	31	227	3,671	16	242	4,139	17
1931	4	147	37	198	3,540	18	202	3,687	18
1932	6	165	28	75	2,481	33	81	2,646	33
1933	11	349	32	67	2,893	43	78	3,242	42
1934	13	287	22	106	1,873	18	119	2,160	18
1935	3	249	83	77	3,015	39	80	3,264	41
1936	7	117	17	182	4,590	25	189	4,707	25
1937	3	91	30	136	4,461	33	139	4,552	33
1938	2	133	67	76	3,184	42	78	3,317	43
1939	7	457	65	51	1,678	33	58	2,135	37
1940	8	888	111	78	3,013	39	86	3,901	45
1941	15	169	11	98	2,266	23	113	2,435	22
1942	33	1,213	37	183	4,239	23	216	5,452	25
1943	45	1,123	25	134	3,862	29	179	4,985	28
1944	27	796	29	118	3,323	28	145	4,119	28
1945	22	755	34	135	3,505	26	157	4,260	27
1946	31	1,045	34	197	4,130	21	228	5,175	23
1947	29	1,588	55	197	4,990	25	226	6,578	29
1948	16	935	58	181	4,642	26	197	5,577	28
1949	17	467	27	153	3,345	22	170	3,812	22
1950	25	810	32	153	3,825	25	178	4,635	26
1951	21	818	39	100	2,381	24	121	3,199	26
1952	19	583	31	111	2,296	21	130	2,879	22
1953	12	487	41	114	2,882	25	126	3,369	27
Total	537	16,246	30	4,420	102,536	23	4,957	118,782	24

The Competition

This competition is one of several conducted by the Bureau of Mines for the promotion of safety in the mineral industries of the United States. The National Crushed Stone Association Safety Competition is conducted under the same rules as the National Safety Competition and the same records submitted by participating companies are used in both contests. However, there are two additional requirements for the crushed stone competition. The operation must have commercial production of crushed stone and the company must be a member of the Association. Application forms and rules of the contest may be secured from the Accident Analysis Branch, Health and Safety Division, Bureau of Mines, Department of the Interior, Washington 25, D. C.

Survey Shows Highway Improvement Trend

A wide variation among states in the over-all trend of highway improvement is disclosed in a survey by the National Highway Users Conference covering revenues and expenditures by state highway departments from 1952 to 1956.

In analyzing survey results to date, based on reports received from 41 states, Roy E. Jorgensen, NHUC Engineering Counsel, points out that the estimates for 1955 and 1956 are based on existing fiscal provisions which may be changed in some states as financing arrangements are modified.

The most significant aspect of the survey to date is the comparison of highway construction expenditures from 1952 to 1956, since these figures indicate the degree to which modernization of the highway system has been stepped up. They reflect the increased authorizations of federal aid (75 per cent between 1952 and 1956), the provision of bond financing in some states, and increased highway revenue from regular state fund sources. They also reflect such reductions in revenue as may result from exhaustion or reduction in bond funds or reduction in current revenue for state highway construction.

Large Increase Seen

For the 38 states reporting for both 1952 and 1956 (three states carried estimates only through 1955), there is an estimated increase in state highway construction of 67 per cent over the five-year period.

Of this total, 7 states anticipate increases exceeding 100 per cent; 14 states, 50 to 100 per cent; 13 states, 0 to 50 per cent; and 4 states expect decreases.

The over-all estimated increase in construction expenditures for these 38 states is from $1,123 million in 1952 to $1,877 million in 1956. Estimating the expenditures of all 48 states on the same scale, state highway construction can be expected to total $2,839 million nationally in 1956, as against $1,700 million in 1952.

Toll Road Figures

All figures and percentages exclude toll road projects. Present indications are that construction of toll facilities in 1956 will be progressing at the rate of about $800 million a year, compared with about $266 million in 1952.

Adding these figures to state highway construction furnishes a comparison for all major highway work —both toll and toll-free—of $3.64 billion in 1956 as against $197 billion in 1952.

Illinois, Missouri and Ohio anticipate increases exceeding 100 per cent due to established increases in tax and fee rates, plus Federal aid, all definitely ear-marked for highways.

Delaware, New York and Rhode Island, all general fund states with no ear-marking, also expect increases topping 100 per cent. These states are, however, dependent on legislative appropriations not yet made.

Nevada, the state most dependent on federal aid, is the seventh state that anticipates a more than 100 per cent boost in construction expenditures.

Estimate Decreases

Of the 4 states estimating decreases in construction expenditures, 3—Massachusetts (—4 per cent), North Carolina (—55 per cent) and Oregon (—34 per cent)—are influenced by the bond funds on which they have been relying heavily. Massachusetts, actually, expects to maintain approximately the same high level of construction of the past several years. North Carolina had a $200 million bond issue which is now completely exhausted as a source of construction funds, and Oregon, apparently, also will have exhausted its bond funds during the current year.

Nebraska, which foresees a 52 per cent decrease in construction expenditures, has one cent of its motor fuel tax expiring in May 1955. This fact, coupled with expected difficulty in taking up federal aid funds available, accounts for the reduced expenditures forecast for 1956.

Detailed data obtained in the survey is being distributed to Highway Users in the respective states. —*NHUC Highlights, September 1954*

Manufacturers Division — National Crushed Stone Association

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These associate members are morally and financially aiding the Association in its efforts to protect and advance the interests of the crushed stone industry. Please give them favorable consideration whenever possible.

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Allis-Chalmers Mfg. Co.
Milwaukee 1, Wis.
Crushing, Screening, Washing, Grinding, Cement Machinery; Motors; Texrope Drives; Centrifugal Pumps; Tractors

American Cyanamid Co.
Explosives Department
30 Rockefeller Plaza, New York 20, N. Y.
Explosives and Blasting Supplies

American Manganese Steel Division
American Brake Shoe Co.
109 North Wabash Ave., Chicago 2, Ill.
Manganese Steel Castings, Power Shovel Dippers, Material Handling Pumps, Reclamation and Hard-Facing Welding Materials

American Pulverizer Co.
1249 Macklind Ave., St. Louis 10, Mo.
Manufacturers of Ring Crushers and Hammermills for Primary and Secondary Crushing

American Steel & Wire Division
Rockefeller Bldg., 614 Superior Ave., N. W., Cleveland 13, Ohio
Wire Rope, Aerial Wire Rope Tramways, Electrical Wires and Cables, Welded Wire Fabric, Concrete Reinforcing, Wire Nails, Fencing, Netting

Aquadyne Corp.
62 LaSalle Road, West Hartford, Conn.
"Wet Water"

Atlas Powder Co.
Wilmington 99, Del.
Industrial Explosives and Blasting Supplies

Bacon-Greene & Milroy
29 Washington Ave., Hamden 14, Conn.
"Farrel-Bacon" Jaw Crushers for Primary and Secondary Operations, Conveyors, Elevators, Rolls, Screens

Baker-Lull Corp.
314 West 90th St., Minneapolis 20, Minn.
Shovel Loaders (Front End)

Baldwin-Lima-Hamilton Corp.
Construction Equipment Division
South Main St., Lima, Ohio
Power Shovels, Draglines, Cranes, Bins, Conveyors and Idlers, Crushers and Pulverizers, Feeders, Plants—Crushing and Portable, Washing Equipment

Barber-Greene Co.
400 North Highland Ave., Aurora, Ill.
Portable and Permanent Belt Conveyors, Belt Conveyor Idlers, Bucket Loaders Both Wheel and Crawler Mounted, Asphalt Mixers and Finishers, Coal Handling Machines

Brunner & Lay Rock Bit Corp.
350 Depot St., Asheville, N. C.
Tungsten Carbide Detachable Bits, "Rock Bit" Drill Steel Inlaid with Tungsten Carbide, Carbon Hollow Drill Steel, Alloy Hollow Drill Steel

Buchanan, C. G., Crushing Machinery Div.
Birdsboro Steel Foundry & Machine Co.
1941 Furnace St., Birdsboro, Pa.
Primary and Secondary Crushers and Rolls

Bucyrus-Erie Co.
South Milwaukee, Wis.
Excavating, Drilling, and Material Handling Equipment

Buda Co.
Division of Allis-Chalmers Mfg. Co.
154th St. and Commercial Ave., Harvey, Ill.
Diesel and Gasoline Engines; Material Handling Equipment; Lifting Jacks; Earth Drills and Maintenance of Way Equipment

Cape Ann Anchor & Forge Co.
P.O. Box 360, Gloucester, Mass.
"Cape Ann" Forged Steel Drop Balls

Caterpillar Tractor Co.
Peoria 8, Ill.
Track-Type Tractors, Bulldozers, Earthmoving Scrapers, Motor Graders, Heavy-Duty Off-Road Hauling Units, Diesel Engines, Diesel Electric Generating Sets, Front End Shovels for Tractors or Tractor Loaders, Wheel-Type Tractors

Chain Belt Co.
P. O. Box 2022, Milwaukee 1, Wis.
Rex Conveyors, Elevators, Feeders, Idlers, Elevator Buckets, Drive and Conveyor Chains, Sprockets, Bearings, Pillow Blocks, Power Transmission Equipment, Portable Self-Priming Pumps

Clark Equipment Co.
Construction Machinery Division
300 Miller St., Benton Harbor, Mich.
Truck Mounted and Crawler Excavator Cranes—3/8, 1/2, 3/4 Cu. Yd.; Tractor Shovels—15 Cu. Ft. Through 2 1/4 Cu. Yd.

Manufacturers Division—National Crushed Stone Association
(continued)

Continental Gin Co.

4500 Fifth Ave., S., Birmingham 2, Ala.

Conveyors—Belt, Screw, Flight and Underground Mine; Elevators—Bucket and Screw; Feeders—Apron, Belt, Reciprocating, Table, and Screw; Drives—V-Belts, Chains and Sprockets, Gears and Speed Reducers

Contractors and Engineers

470 Fourth Ave., New York 16, N. Y.

Magazine of Modern Construction

Cross Engineering Co.

P. O. Box 507, Carbondale, Pa.

Cross Perforated Steel Segments, Sections, Decks, for Vibrating, Shaking, Revolving, and Other Types of Screening Equipment

Cummins Engine Co., Inc.

Fifth and Union Sts., Columbus, Ind.

Lightweight Highspeed Diesel Engines (60-600 Hp.) for: On-Highway Trucks, Off-Highway Trucks, Buses, Tractors, Earthmovers, Shovels, Cranes, Industrial and Switcher Locomotives, Air Compressors, Logging Yarders and Loaders, Oil Well Drilling Rigs, Centrifugal Pumps, Generator Sets and Power Units, Work Boats and Pleasure Craft

Deister Machine Co.

1933 East Wayne St., Fort Wayne 4, Ind.

Deister Vibrating Screens, Classifiers, Washing Equipment

Detroit Diesel Engine Division General Motors Corp.

13400 West Outer Drive, Detroit 28, Mich.

Light Weight, Compact 2 Cycle Diesel Engines and "Package Power" Units for All Classes of Service

Diamond Iron Works, Division of Goodman Manufacturing Co.

1728 North Second St., Minneapolis 11, Minn.

Jaw and Roll Crushers; Vibrator, Revolving, and Scrubber Screens; Drag Washers; Bucket Elevators; Belt Conveyors; Bins; Apron and Plate Feeders; Portable Gravel and Rock Crushing, Screening, and Washing Plants; Stationary Crushing, Screening, and Washing Plants; Hammermills

Du Pont, E. I., de Nemours & Co.

Wilmington 98, Del.

Explosives and Blasting Supplies

Eagle Iron Works

129 Holcomb Ave., Des Moines 13, Iowa

Fine Material Screw Washers—Classifiers—Dehydrators; Coarse Material Screw and Log Washers—Dewaterers; Water Scalping and Fine Material Settling Tanks; Drop Balls—Ni-Hard and Semi-Steel; "Swintek" Screen Chain Cutter Dredging Ladders

Easton Car & Construction Co.

Easton, Pa.

Off-Highway Transportation: Dump Trailers, Truck Bodies, and Cars for Mines, Quarries, and Earth Moving Projects

Ensign-Bickford Co.

Simsbury, Conn.

Primacord-Bickford Detonating Fuse and Safety Fuse

Euclid Division General Motors Corp.

1361 Chardon Road, Cleveland 17, Ohio

Heavy-Duty Trucks and Dump Trailers for "Off-Highway" Hauls, Loaders for Earth Excavation, Single and Twin Engine Earth Moving Scrapers

Frog, Switch & Mfg. Co.

Carlisle, Pa.

Manganese Steel Department—Manufacturers of "Indian Brand" Manganese Steel Castings for Frogs, Switches, and Crossings, Jaw and Gyratory Crushers, Cement Mills, Mining Machinery, Etc., Steam Shovel Parts, Other Miscellaneous Manganese Steel Castings

General Electric Co.

1 River Road, Schenectady 5, N. Y.

Electric Motors, Controls, Locomotives, Welding Equipment, Coordinated Electric Drives for: Shovels, Drag Lines, Conveyors, Hoists, Cranes, Crushers, Screens, Etc.; Coordinated Power Generating and Distributing Systems Including Generators, Switchgear, Transformers, Cable, Cable Skids, Load Center Substations

Gill Rock Drill Co.

Lebanon, Pa.

Well Drill Tools and Supplies

Goodyear Tire & Rubber Co., Inc.

Akron 16, Ohio

Airfoam; Mechanical Goods—Belting (Conveyor, Elevator, Transmission), Hose (Air, Water, Steam, Suction, Miscellaneous), Chute Lining (Rubber); Rims (Truck and Tractor); Storage Batteries (Automobile, Truck, Tractor); Tires (Automobile, Truck, Off-the-Road); Tubes (Automobile, Truck, Off-the-Road, LifeGuard, Safety Tubes, Puncture Seal Tubes)

Gruendler Crusher and Pulverizer Co.

2915 North Market St., St. Louis 6, Mo.

Rock and Gravel Crushing, Screening and Washing Plants, Jaw Crushers, Roll Crushers, Hammermills, Lime Pulverizers

Manufacturers Division—National Crushed Stone Association
(continued)

Gulf Oil Corp.
Gulf Refining Co.
Gulf Bldg., Pittsburgh 19, Pa.
Lubricating Oils, Greases, Gasoline and Diesel Fuels

Haiss, George, Mfg. Co., Inc.
Division of Pettibone Mulliken Corp.
5720 Empire State Bldg., New York 1, N. Y.
Bucket Loaders, Buckets, Portable and Stationary Conveyors, Car Unloaders

Harnischfeger Corp.
4400 West National Ave., Milwaukee 14, Wis.
A Complete Line of Power Excavating Equipment, Overhead Cranes, Hoists, Smootharc Welders, Welding Rod, Motors and Generators, Diesel Engines

HarriSteel Products Co.
420 Lexington Ave., New York 17, N. Y.
Woven Wire Screen Cloth

Hayward Co.
50 Church St., New York 7, N. Y.
Orange Peel Buckets, Clam Shell Buckets, Electric Motor Buckets, Automatic Take-up Reels

Heidenreich, E. Lee, Jr.
Consulting Engineers
75 Second St., Newburgh, N. Y.
Plant Layout, Design, Supervision; Open Pit Quarry Surveys; Appraisals—Plant and Property

Hendrick Mfg. Co.
Carbondale, Pa.
Perforated Metal Screens, Perforated Plates for Vibrating, Shaking, and Revolving Screens; Elevator Buckets; Test Screens; Wedge Slot Screens; Open Steel Floor Grating

Hercules Powder Co.
Wilmington 99, Del.
Explosives and Blasting Supplies

Hetherington & Berner Inc.
701-745 Kentucky Ave., Indianapolis 7, Ind.
Asphalt Paving Machinery, Sand and Stone Dryers

Hewitt-Robins Incorporated
666 Glenbrook Road, Stamford, Conn.
Belt Conveyors (Belting and Machinery); Belt and Bucket Elevators; Car Shake-outs; Feeders; Industrial Hose; Screen Cloth; Sectional Conveyors; Skip Hoists; Stackers; Transmission Belting; Vibrating Conveyors, Feeders, and Screens; Design and Construction of Complete Plants

Hoyt Wire Cloth Co.
Abraso St., P. O. Box 22, Lancaster, Pa.
Aggregate Wire Screens Made of Supertough and Abraso Wire—Smoothtop, Longslot, Oblong Space and Double Crimp Construction—For All Makes of Vibrators

Hughes Tool Co.
P. O. Box 2539, Houston 1, Texas
Drills and Drilling Equipment

Illinois Powder Mfg. Co.
506 Olive St., St. Louis 1, Mo.
Gold Medal Explosives

Ingersoll-Rand Co.
11 Broadway, New York 4, N. Y.
Rock Drills, Quarrymaster Drills, Jackbits, Bit Reconditioning Equipment, Portable and Stationary Air Compressors, Air Hoists, Slusher Hoists, Air Tools, Diesel Engines, Pumps

Insley Manufacturing Corp.
801 North Olney St., Indianapolis 6, Ind.
Concrete Carts and Buckets; 1/2 to 2 Cu. Yd. Cranes and Shovels—5 to 30 Tons Capacity

International Harvester Co.
P. O. Box 270, Melrose Park, Ill.
Motor Trucks, Diesel and Gasoline Power Units; Crawler Tractors; Industrial Wheel Tractors

Iowa Manufacturing Co.
916 16th St., N.E., Cedar Rapids, Iowa
Rock and Gravel Crushing, Screening, Conveying and Washing Plants, Hot and Cold Mix Asphalt Plants, Stabilizer Plants, Impact Breakers, Screens, Elevators, Conveyors, Portable and Stationary Equipment, Hammermills, Bins

Jaeger Machine Co.
550 West Spring St., Columbus 16, Ohio
Portable and Stationary Air Compressors, Self-Priming Pumps, Truck Mixers, Concrete Mixers, Road Paving Machinery, Hoists and Towers; Rubber-Tired Front End Loaders

Jeffrey Manufacturing Co.
East First Ave., Columbus 16, Ohio
Elevator Buckets; Car Pullers; Chains; Conveyors: Belt, Drag, Apron, Vibrating; Idlers; Crushers; Pulverizers; Elevators; Feeders; Pillow Blocks; Stationary Plants; Screens

Johnson-March Corp.
1724 Chestnut St., Philadelphia 3, Pa.
Dust Allaying Equipment

Manufacturers Division—National Crushed Stone Association
(continued)

Joy Manufacturing Co.
333 Henry W. Oliver Bldg., Pittsburgh 22, Pa.
Drills: Blast-Hole, Wagon, Rock, and Core; Air Compressors: Portable, Stationary, and Semi-Portable; Aftercoolers; Portable Blowers; Carpullers; Hoists; Multi-Purpose and Portable Rock Loaders; Air Motors; Trench Diggers; Belt Conveyors; "Spaders"; "String-a-Lite" (Safety-Lighting-Cable); Backfill Tampers; Drill Bits: Rock and Core

Kennedy-Van Saun Mfg. & Eng. Corp.
2 Park Ave., New York 16, N. Y.
Crushing, Screening, Washing, Conveying, Elevating, Grinding, Complete Cement Plants, Complete Lime Plants, Complete Lightweight Aggregate Plants, Synchronous Motors, Air Activated Containers for Transportation of Pulverized Material, Cement Pumps, and Power Plant Equipment

Kensington Steel Co.
505 Kensington Ave., Chicago 28, Ill.
Oro Alloy and Manganese Steel Castings: For Shovels—Dipper Teeth, Crawler Treads; For Crushers—Jaw Plates, Concaves, Mantles, Bowl Liners; For Pulverizers—Hammers, Grate Bars, and Liners; For Elevators and Conveyors—Chain, Sprockets; For Tractors—Rail Links and Grouser Plates; Drag Line Chain

King Powder Co., Inc.
Cincinnati, Ohio
Detonite, Dynamites, and Blasting Supplies

Koehring Co.
3026 West Concordia Ave., Milwaukee 16, Wis.
Excavating, Hauling, and Concrete Equipment

Le Roi Co.
Cleveland Rock Drill Division
12500 Berea Road, Cleveland 11, Ohio
Air Compressors—Portable 60 Cfm. to 600 Cfm. Gas or Diesel; Tractairs—Combined Tractor with 105 Cfm. Air Compressor; Engines; Generator Sets; Rock and Wagon Drills; Jumbo Drill Rigs, Drifters, Stopers, Self Propelled Drill Rigs; Concrete Mixers; Front End Loaders

Linde Air Products Co., Division of Union Carbide and Carbon Corp.
30 East 42nd St., New York 17, N. Y.
Oxygen, Acetylene, Welding and Jet Piercing Equipment and Supplies

Link-Belt Co.
300 West Pershing Road, Chicago 9, Ill.
Complete Stone Preparation Plants; Conveyors, Elevators, Screens, Washing Equipment, Speed-O-Matic Shovels—Cranes—Draglines and Power Transmission Equipment

Link-Belt Speeder Corp.
1201 Sixth St., S. W., Cedar Rapids, Iowa
Complete Line of Power Hydraulically Controlled Cranes, Shovels, Trench Hoes, Draglines, Clamshells, 1/2 to 3 Yd. Capacities. Available on Crawler Base or Rubber Tire Mounting

Ludlow-Saylor Wire Cloth Co.
634 South Newstead Ave., St. Louis 10, Mo.
Woven Wire Screens and Wire Cloth of Super-Loy, Steel, and All Commercial Alloys and Metals

Mack Motor Truck Corp.
350 Fifth Ave., New York 1, N. Y.
On- and Off-Highway Trucks, Tractor-Trailers, Six-Wheelers, from 5 to 30 Tons Capacity, both Gasoline- and Diesel-Powered

Marion Power Shovel Co.
617 West Center St., Marion, Ohio
A Complete Line of Power Shovels, Draglines, and Cranes

McLanahan & Stone Corp.
200 Wall St., Hollidaysburg, Pa.
Complete Pit, Mine, and Quarry Equipment—Crushers, Washers, Screens, Feeders, Etc.

Murphy Diesel Co.
5317 West Burnham St., Milwaukee 14, Wis.
Engines and Power Units—90 to 246 Hp.; Generator Sets—60 to 154 Kw.; Marine Engines—90 to 225 Hp.; Dual-Fuel Engines—135 to 180 Hp.; Mechanical and Electric Power Simultaneously

National Container Corp. of Ohio
Multi-Wall Paper Bag Division
Jaite, Ohio
Multi-Wall Paper Bags, Sewn and Pasted Style for Packaging Lime, Cement, Plaster, Etc.

New York Rubber Corp.
100 Park Ave., New York 17, N. Y.
Conveyor Belting: Stonore, Dependable, and Cameo Grades; Transmission Belting: Silver Duck Duroflex, Soft Duck Rugged, Commercial Grade Tractor

Manufacturers Division—National Crushed Stone Association
(continued)

Nordberg Mfg. Co.
3073 South Chase Ave., Milwaukee 7, Wis.
Symons Cone and Gyratory Crushers; Gyradisc; Grinding Mills; Stone Plant and Cement Mill Machinery; Vibrating Screens and Grizzlies; Diesel Engines and Diesel Driven Generator and Pumping Units; Mine Hoists; Track Maintenance Machinery

Northern Blower Co.
6409 Barberton Ave., Cleveland 2, Ohio
Dust Collecting Systems, Fans—Exhaust and Blower

Northwest Engineering Co.
135 South LaSalle St., Chicago 3, Ill.
Shovels, Cranes, Draglines, Pullshovels

Olin Industries, Inc.
Explosives Division
East Alton, Ill.
Dynamite, Black Powder, Blasting Caps, Blasting Supplies

Osgood-General
P. O. Box 515, Marion, Ohio
Power Shovels, Cranes, Draglines, Hoes, Etc., 3/8 to 2 1/2 Cu. Yd.

Pennsylvania Crusher Co.
323 South Matlack St., West Chester. Pa.
Single Roll Crushers, Impactors, Hammermills, Ring Type Granulators, Kue-Ken Jaw Crushers, Kue-Ken Gyracones, Dixie Non-Clog and Standard Hammermills

Pettibone Mulliken Corp.
4710 West Division St., Chicago 51, Ill.
Material Handling Buckets, Clamshells, Draglines, Pullshovels, Dippers, Shovel Dippers, Pumps, Hammermills, Front End Loaders, Bucket Conveyor Loaders, Fork and Bucket Loaders, Speed Swing Loaders, Speed Swing Yard Cranes, Motor Graders, Manganese Steel Castings

Pioneer Engineering Works, Inc.
1515 Central Ave., N. E., Minneapolis 13, Minn.
Jaw Crushers, Roll Crushers (Twin and Triple), Vibrating and Revolving Screens, Feeders (Mechanical, Grizzly, Apron, and Pioneer-Oro), Belt Conveyors, Portable and Stationary Crushing and Screening Plants, Washing Plants, Mining Equipment, Cement and Lime Equipment, Asphalt Plants and Finishers

Pit and Quarry Publications, Inc.
431 South Dearborn St., Chicago 5, Ill.
Pit and Quarry, Pit and Quarry Handbook, Pit and Quarry Directory, Concrete Manufacturer, Concrete Industries Yearbook

Productive Equipment Corp.
2926 West Lake St., Chicago 12, Ill.
Vibrating Screens

Quaker Rubber Corp.
Division of H. K. Porter Co. of Pittsburgh
Tacony and Milnor Sts., Philadelphia 24, Pa.
Conveyor Belts, Hose, and Packings

Radio Corporation of America
Engineering Products Department
Industrial Equipment Section
Front and Cooper Sts., Bldg. 15-1, Camden 2, N. J.
Electronic Metal Detectors

Rock Products
309 West Jackson Blvd., Chicago 6, Ill.

Rogers Iron Works Co.
11th and Pearl Sts., Joplin, Mo.
Jaw Crushers, Roll Crushers, Hammermills, Vibrating Screens, Revolving Screens and Scrubbers, Apron Feeders, Reciprocating Feeders, Roll Grizzlys, Conveyors, Elevators, Portable and Stationary Crushing and Screening Plants, Mine Hoists, Drill Jumbos and Underground Loaders

Screen Equipment Co., Inc.
1754 Walden Ave., Buffalo 25, N. Y.
Seco Vibrating Screens

Simplicity Engineering Co.
Durand, Mich.
Simplicity Gyrating Screens, Horizontal Screens, Simpli-Flo Screens, Tray Type Screens, Heavy Duty Scalpers, D'Watering Wheels, D'Centegrators, Vibrating Feeders, Vibrating Pan Conveyors

SKF Industries, Inc.
Front St. and Erie Ave., P. O. Box 6731, Philadelphia 32, Pa.
Anti-Friction Bearings—Self-Aligning Ball, Single Row Deep Groove Ball, Angular Contact Ball, Double Row Deep Groove Ball, Spherical Roller, Cylindrical Roller, Ball Thrust, Spherical Roller Thrust; Pillow Block and Flanged Housings—Ball and Roller

Smith Engineering Works
532 East Capitol Drive, Milwaukee 12, Wis.
Gyratory, Gyrasphere, Jaw and Roll Crushers, Vibrating and Rotary Screens, Gravel Washing and Sand Settling Equipment, Elevators and Conveyors, Feeders, Bin Gates, and Portable Crushing and Screening Plants

Manufacturers Division—National Crushed Stone Association
(concluded)

Stedman Foundry & Machine Co., Inc.
Aurora, Ind.
Stedman Impact-Type Selective Reduction Crushers, 2-Stage Swing Hammer Limestone Pulverizers, Multi-Cage Limestone Pulverizers, Vibrating Screens

Stephens-Adamson Mfg. Co.
Aurora, Ill.
Belt Conveyors, Elevators, Feeders, Car Pullers, Screens, Skip Hoists, Complete Plants

Talcott, W. O. & M. W., Inc.
91 Sabin St., Providence 1, R. I.
Belt Fasteners, Belt Lacing, Conveyor Belt Fasteners, and Patch Fasteners

Taylor-Wharton Iron & Steel Co.
High Bridge, N. J.
Manganese and other Special Alloy Steel Castings; Dipper Teeth, Fronts and Lips; Crawler Treads; Jaw and Cheek Plates; Mantles and Concaves; Pulverizer Hammers and Liners; Asphalt Mixer Liners and Tips; Manganese Nickel Steel Welding Rod and Plate

Thew Shovel Co.
East 28th St. and Fulton Rd., Lorain, Ohio
"Lorain" Power Shovels, Cranes, Draglines, Clamshells, Hoes, Scoop Shovels on Crawlers and Rubber-Tire Mountings. Diesel, Electric, and Gasoline, 3/8 to 2 Yd. Capacities

Torrington Co.
Bantam Bearings Division
3702 West Sample St., South Bend 21, Ind.
Anti-Friction Bearings; Self-Aligning Spherical, Tapered, Cylindrical, and Needle Roller; Roller Thrust; Ball Bearings

Travel Drill Co.
P. O. Box 1124, Raleigh, N. C.
"Travel Drill"—Mobile Drill for Secondary Drilling in Quarries and Open Pit Work

Traylor Engineering & Mfg. Co.
Allentown, Pa.
Stone Crushing, Gravel, Lime, and Cement Machinery

Trojan Powder Co.
17 North 7th St., Allentown, Pa.
Explosives and Blasting Supplies

Tyler, W. S., Co.
3615 Superior Ave., N. E., Cleveland 14, Ohio
Woven Wire Screens; Ty-Rock, Tyler-Niagara and Ty-Rocket (Mechanically Vibrated) Screens; Hum-mer Electric Screens; Ro-Tap Testing Sieve Shakers; Tyler Standard Screen Scale Sieves, U. S. Sieve Series

Unit Crane & Shovel Corp.
6411 West Burnham St., Milwaukee 14, Wis.
1/2 and 3/4 Cu. Yd. Crawler and Rubber Mounted Shovels, Clamshells, Draglines

Universal Engineering Corp.
625 C Ave., N. W., Cedar Rapids, Iowa.
Jaw Crushers, Roll Crushers, Twindual Roll Crushers, Hammermills, Impact Breakers, Complete Line of Crushing, Screening, Washing and Loading Plants, Either Stationary or Portable for Sand and Gravel, Stone, Aggregates or Aglime, Asphalt Plants

Vibration Measurement Engineers
7665 Sheridan Road, Chicago 26, Ill.
Seismographic and Airblast Measurements, Seismological Engineering, Blasting Complaint Investigations, Expert Testimony in Blasting Litigation; Nation-wide Coverage

Werco Steel Co.
2151 East 83rd St., Chicago 17, Ill.
Castings—Manganese, Alloy Steel; Screen Plates—Perforated Steel Screen Sections and Decks; Buckets; Chains; Belt Conveyors, Idlers; Dipper—Shovel; Drop Balls; Wire Cloth; Wire Rope and Related Products

Weston Dump Body Co.
326 S.W. 11th St., Des Moines 9, Iowa
Combination Lime, Sand, and Gravel Body; Special Bodies for Quarry and Pit Work

Wheeler, Delbert
2408 Harrison St., Topeka, Kans.
Wheeler Testing Vibrators

White Motor Co.
842 East 79th St., Cleveland 1, Ohio
On- and Off-Highway Trucks and Tractors—Gasoline- and Diesel-Powered; Industrial Engines, Power Units, Axles, Special Machine Assemblies; All Classes of Service